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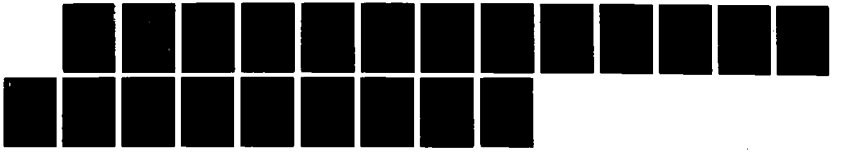

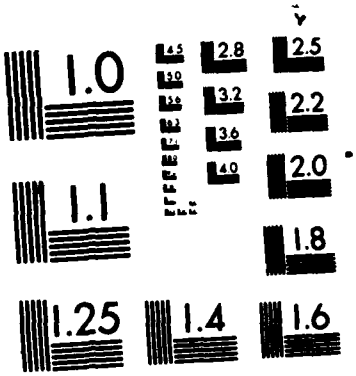

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FOREIGN TECHNOLOGY DIVISION

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by

Jerzy Kolendowski and Marek Ksiezyk

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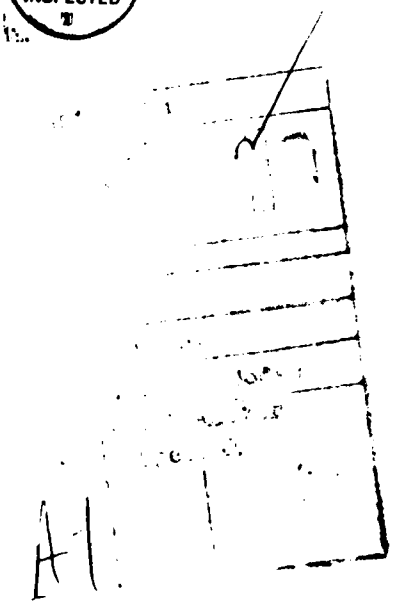

COMPUTERS IN THE SERVICE OF SCIENCE

by Jerzy Kolendowski and Marek Ksiezyk, The Regional Computation Center CYFRONET--Cracow

In the various equipment expenses of scientific institutions, a considerable part is designated for the formation and maintenaince of computation centers. The majority of centers which perform scientific and technical computation have been developed in the last decade. As a rule they are equipped with multiple access computers. The terminal networks, connected with them over a data transmission line, as a rule, have a regional character, but educational institutions do seek tie-ins to large computer networks with an international range.

The tremendous need for scientific computation is causing the constant growth of computation capability, which can lead ot the organizational detachment of centers from their mother institutions.

Sometimes it is established in advance that the computational capability installed in the initial period will considerably exceed the real needs of the university or institute. This typical lead period encompasses a shorter period than planned. Characteristic is the example of the University of Illinois's (Champaign) center with its gigantic computational power. With the installation of new computers in the current year it has been established that the initial use of the system's power is barely 20%.

Some educational centers have given up the idea of purchasing their own computers and are leasing the most modern equipment. This is how the interdepartmental computation center of the Technical High School of Vienna operates.

Taking into account the multidisciplinary character of computation, every center seeks the maximum colleciton of program libraries. These are either their own libraries or are purchased or subscribed to (a very useful form of programming access). The following are among the most popular libraries: the International Mathematical and Statistical Library (IMSL), the Nottingham Algorithms Group Library (NAG) and the Statistical Package for the Social Sciences Library (SPSS). The specialization of some centers in defined themes deserves attention. So, for example, in cooperation with a group of scientists, the University of Oslo's computation center has obtained excellent results in the field of simulated languages. Another example is the working out of the Minnesota FORTRAN compiler (MNF) by the computation center of the University of Minnesota in Minneapolis.

In interuniversity computation centers work scientific boards among which are representatives of the interested universities. As the tasks of these boards are such issues as the allotment of computer time among the individual institutions and the establishment of priorities, of which scientific disciplines, whose development requires computer use, occupy first place. The dominant user groups are usually physicists, although in some of the large foreign university centers, psychologists most frequently use the computers. The allotment of computer time does not cause conflicts as long as reserve time exists. When this is not the case (system overload) it is difficult to establish fair (objective) criteria.

The appearance of many interinstitutional centers and their rapid development is providing a good deal of very valuable material for the strategy and tactics of scientific development on the regional or state level.

The Cracow interinstitutional center has been in operation for two years,

but is still barely known in the country.

In 1972 in accordance with the decision of the chariman of the Council of Ministers, the appropriate means were designated for the purchase of the latest computerized subscription system for use by the scientific institutions of the Cracow region. In 1975, after an arduous period of preparation, such a system was realized in the Regional Computation Center (SCO) CYFRONET--Cracow.

The Center--an independent organizational unit--is directly subordinate to the Ministry of Science, Higher Education and Technology.

THE EQUIPMENT

The SCO CYFRONET is equipped with the CYBER 72-16 computer produced by the Control Data Corporation. It posesses 1 central processor, 10 peripheral processors, operational memory with a 60 bit 96K word capacity, 3 disc memory units with 118 mln character capacities, 8 tape memory units, 2 card readers, a reader/paper tape perforator, 2 line printers and a plotter operating in an off-line mode.

Also included in the system are 6 terminals designated for use in the batch mode (a t.v. monitor, card reader and line printer) and 14 teleprinter terminals. The terminals are located in 10 higher educational and scientific institutions, within a radius of several kilometers from the Center. All the terminals are connected with the Center by means of leased telephone lines.

Table 2, which contains the characteristics of the individual equipment, provides the system's configuration.

THE SOFTWARE

The CYBER 72-16 operates under the control of the SCOPE 3.4.4. operating system (present level 439). The terminal's operation is performed under the control of the INTERCOM s.5 system. Within the framework of the system's software, characterized in table 3, are over 20 programming languages and useful programs.

The SCO CYFRONET places great importance on the compilation of program libraries and their propagation among users. Presently, the center dispenses around 2300 programs grouped in seven libraries and specialized packages, for example SCEPTRE, ECAP CENPLOT. All the programs are recorded on discs as permanet sets (in the complex and original form). This assures the users a suitable and immediate access to the libraries.

This large set of program libraries allows the scientific worker to find the optimal solution to a great many problems in varied fields, for example:

--linear algebra

--polynomial operations

--interpolation and approximation

--special functions

--statistical analyses

--probability accessments

--numerical integration and differentiation

--differential equations

--the graphic presentation of results

--data transformation

--set sorting and operation

--optimization

--nuclear physics and chemistry

Table 1. Some inter-institutional computation centers in the world

1 Nazwa ośrodka	2 Rok utworzenia	3 Wyposażenie	4 Sieć	5 Charakter ośrodka
University of London Computer Centre	1966	CDC 6600 CDC 6400 CDC 7600 CYBER 72	a) terminalowa b) komputerowa	regionalny
Imperial College Computer Centre, London	1964	CDC 6400 CYBER 73 (KCS)	a) terminalowa b) komputerowa	uczelniany
University of Manchester Regional Computer Centre	1970	CDC 7600 CYBER 72 ICL 1906A	a) terminalowa b) komputerowa	regionalny
Centrum Obliczeniowe Zjednoczonego Instytutu Badań Jądrowych w Dubnej*)	1955	BESM-6 CDC 6500	terminalowa	instytutowy
Regionales Rechenzentrum für Niedersachsen, Hannover	1971	CYBER 76 CYBER 74 CYBER 73 (ECS)	terminalowa	regionalny
Rechenzentrum der Rhein.-Westf. Technischen Hochschule Aachen	1956	CDC 6400 CYBER 175	terminalowa	uczelniany
European Organization for Nuclear Research (CERN), Geneva*)		CDC 7600 CDC 6400 CDC 6500 IBM 370 168	terminalowa	instytutowy
Regnesentralen Blindern-Kjeller Oslo		CYBER 76	terminalowa	regionalny
Centrum Obliczeniowe Węgierskiej Akademii Nauk, Budapeszt*)	1971	CDC 3500	terminalowa	ogólnokrajowy
CYFRONET-AWIERN	1973	CYBER 73	terminalowa	regionalny
Interfakultäres Rechenzentrum der Technischen Hochschule Wien		CYBER 74	terminalowa	uczelniany
Interfakultäres Rechenzentrum der Universität Wien	1974	CYBER 73	terminalowa	uczelniany
University of Illinois Computer Centre		CYBER 175 IBM 360 75 IBM 360,75 IBM 370/168 B-6700	terminalowa	uczelniany
Triangle Universities Computation Center, North Carolina	1965	IBM 360,75 IBM 370/155 IBM 370,155	a) terminalowa b) komputerowa	stanowy

Table 1 (continued)

1. center's name, 2. year of founding, 3. equipment, 4. network, 5. center's character, 6. The Computation Center of the Union Institute of Nuclear Research in Dubna (USSR), 7. The Computation Center of the Hungarian Academy of Sciences, 8. terminal, 9. computer, 10. terminal, 11. computer, 12. terminal, 13. computer, 14. terminal, 15. terminal, 16. terminal, 17. terminal, 18. terminal, 19. terminal, 20. terminal, 21. terminal, 22. terminal, 23. terminal, 24. termianal, 25. computer, 26. regional, 27. educational institution, 28. regional, 29. institutional, 30. regional, 31. educational institution, 32. institutional, 33. regional, 34. national, 35. regional, 36. educational institution, 37. educational institution, 38. educational institution, 39. state

Note *) inserted on account of the similarity to university centers

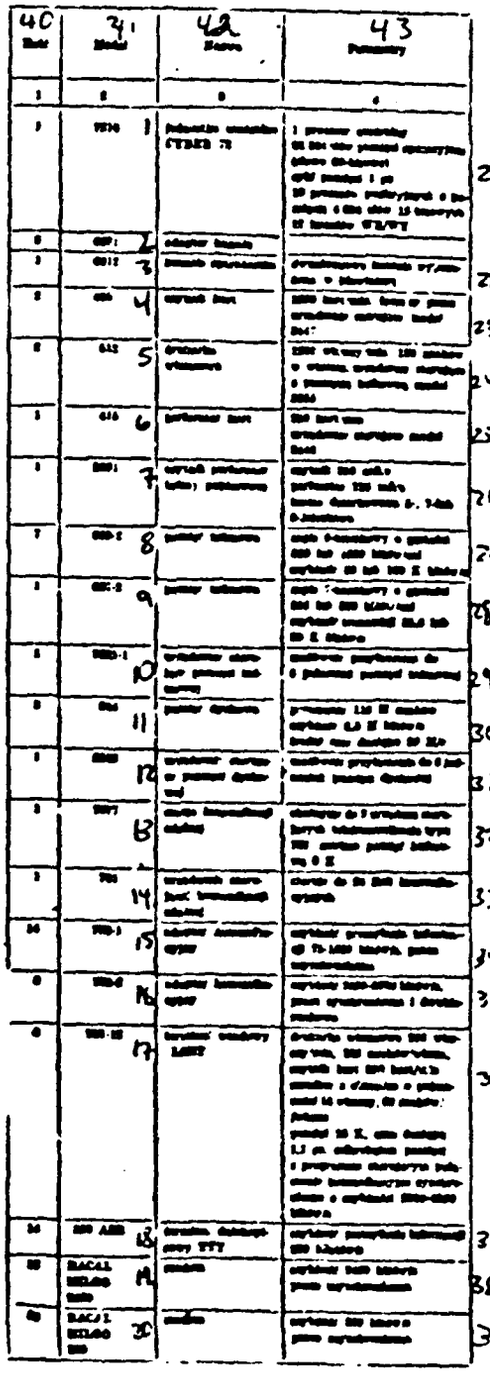

Table 2. Configuration of the computer equipment in the SCO CYFRONET-Cracow

Table 2 (continued)

1. CYBER 72 central unit, 2. channel adapter, 3. operator consol, 4. card reader, 5. line printer, 6. card perforator, 7. reader/paper tape perforator, 8, tape memory, 9. tape memory, 10. paper tape control device, 11. disc memory, 12. disc memory control device, 13. remote communication control station, 14. remote communication control device, 15. communication adapter, 16. communication adapter, 17. LSBT batch terminal, 18. TTY teleprinter terminal, 19. modem, 20. modem, 21. 1 central processor, 98,304 word operating memory (60 bit word), memory cycle 1 μs, 10 peripheral processors with 12 bit 4,096 word memory, 12 input/output channels, 22. double screen consol equipped in the keyboard, 23. 1200 card/min connected by the Model 3447 control device, 24. 1200 line/min, 136 characters a line, Model 3444 device which controls with buffer memory, 25. 250 card/min Model 3446 control device, 26. 350 inch/s reader, 120 inch/s perforator, 5,7 or 8 track perforated tape, 27. 9 track record with 800 or 1600 bit/inch density, 80 or 160 Kbit/s rate, 28. 7 track record with 556 or 800 bit/inch density, 55.6 or 80 Kbit/s transmission rate, 29. the possible addition of 8 tape memory units, 30. 118 M character capacity, 6.8 M bit/s rate, 30 M/s average access rate, 31. the possible addition of 8 disc memory units, 32. serves as telecommunications for 3 type 791 control devices, contains 8 K buffer memory, 33. controls 24 communications lines, 34. 75-1800 bit/s information transmission rate, asynchronous operation, 35. 2400-9600 bit/s rate, synchronized and bidirectional operation, 36. line printer 300 line/min, 136 character/line, 300 card/min card reader, monitor with screen--16 line, 80 character/line capacity, 16 K memory, 1,1 μs access time, memory microdrum with program controlling synchronized communication connection at rates from 2000 to 4800 bit/s, 37. 200 bit/s information transmission rate, 38. 2400 bit/s rate asynchronous operation, 39. 300 bit/s rate

Table 2 (cont.)

40. quantity, 41. model, 42. name, 43. parameters, 44. magnetic tape unit for CALCOMP plotter, 45. 9 track record, equipped with the following programs:, 46. 840 mm paper width, .05 mm step length, off-line mode operation, plotting rate: 90 mm/s along the axis, 127 mm/s perpendicularly

--high energy physics

--biomedical problems

--network programming

--electric circuitry projection.

The alphabetical and divisional lists of programs are worked out for each library, which are also recorded on discs. Up until now not all the users have been able to fully exploit the libraries' wealth of possibilities. However, thanks to CYFRONET's operation, which is intended to propagate the program libraries, a greater and greater interest in these programs has been noted.

From the moment of the installation of the CYFRONET computer system , efforts have been aimed at its utilization. The activity of all of the Center's workers has been directed to this goal. First, it is necessary to turn attention to the function of the system's analysts. In running the system, they introduce successively new levels of the exploitation of the SCOPE operating system and perform local modifications of the system, such as:

--a change of procedure which establishes the priority of tasks in the input sequence (priority is a function of time declared by the user, for which the individual "preferential" tasks are very short),

--the establishment of priority in the output sequence, depending upon the extent of the output set and the way the task is performed (correction--error),

--the constant reservation, "to enter" for short tasks in the perform sequence,

--the program automatically modifying the contents of the operating memory depending upon the system's mode of operation (interactive + batch or batch alone),

Lp.	1 Nazwa		2. Charakterystyka
1	ALGOL 4.1	3	Język do obliczeń numerycznych, implementacja języka ALOGL 60
2	APEX III	4	Pakiet programów do rozwiązania zagadnień programowania liniowego
3	APT 2	5	Język do numerycznego sterowania obrabiarkami
4	BASIC 2.1	6	Język do obliczeń numerycznych zalecany do nauki programowania, z możliwością pracy interakcyjnej
5	COBOL 4.5	7	Język do przetwarzania danych
6	COMPASS 3	8	Assembler dla maszyn CDC serii CYBER 170 CYBER 70 Model 72 73.74, CDC 6000, CDC 7600
7	CSSL 3	9	Język do symulacji procesów ciągłych
8	DDL 1	10	Język do opisu bazy danych
9	FORM	11	Język do przetwarzania danych w systemie SCOPE 3.4.X
10	FTN 4.8	12	Język do obliczeń numerycznych, wersja języka FORTRAN IV.
11	INFOL-2	13	Program w języku FORTRAN przeznaczony do gromadzenia i wyszukiwania informacji, z możliwością pracy interakcyjnej
12	KWIC	14	Program w języku FORTRAN przeznaczony do układu informacji według słów kluczowych występujących w tekście
13	LISP 4.1	15	Język do przetwarzania danych symbolicznych, wersja TEXAS LISP 4.1
14	MIMIC	16	Język do symulacji procesów ciągłych, z możliwością współpracy z podprogramami napisanymi w języku FORTRAN
15	MNF	17	Język do obliczeń numerycznych, wersja języka FORTRAN. Zalecany do nauki programowania w języku FORTRAN ze względu na rozszerzoną diagnostykę
16	PASCAL	18	Język do obliczeń numerycznych i pisania oprogramowania
17	PERT TIME	19	Program do układania harmonogramów
18	QUERY UPDATE 2	20	Język do przetwarzania zbiorów opisanych przez DDL, możliwość pracy interakcyjnej i wsadowej
19	REDUCE	21	Język do przetwarzania danych symbolicznych
20	RUN 2.3	22	Język do obliczeń numerycznych, wersja języka FORTRAN
21	SCHOONSHIP	23	Język do przekształceń wyrażeń algebraicznych
22	SIMULA 67	24	Język do obliczeń numerycznych i symulacji procesów
23	SIMSCRIPT	25	Język do symulacji procesów dyskretnych
24	SNOBOL 4.8	26	Język do przetwarzania tekstów
25	SORT/MERGE	27	Produkt do sortowania i łączenia zbiorów danych w systemie SCOPE 3.4.X
26	SYMPL	28	Język do pisania kompilatorów i programów systemowych

Table 3. The user languages and programs accessible in the SCO CYFRONET-Cracow

Table 3 (cont.)

1. name, 2. characteristic, 3. language for numeric computation, ALGOL 60 language implementation, 4. package of programs for solving line programming problems, 5. language for numeric control of machines, 6. language for numeric computation recommended for programming science, with the possibility of interactive operation, 7. language for data processing, 8. assembler for the CDC of the 17'' CYBER series, CYBER 70 Model 72/73/74, CDC 6000, CDC 7600, 9. language for the simulation of continuous processes, 10. language for data base description, 11. language for data processing in the SCOPE 3.4.X, 12. language for numeric computation, a version of FORTRAN IV, 13. program in FORTRAN designated for information accumulation and search, with possible interactive operation, 14. program in FORTRAN designated for an information system according to key words appearing in the text, 15. language for symbolic data processing, TEXAS LISP 4.1 version, 16. language for the simulation of continuous processes, with possible collaboration with subprograms written in FORTRAN, 17. language for numeric computation, a version of FORTRAN. Recommended for programming science in FORTRAN on account of expanded diagnostics, 18. language for numeric computaiton and program writing, 19. program for setting graphic schedules, 20. language for the processing of sets described by DDL, possible interactive and batch operation, 21. language for symbolic data processing, 22. language for numeric computa on, a version of FORTRAN, 23. language for the transformation of algebraic expressions, 24. language for numeric computation and the simulation of processes, 25. language for the simulation of discrete processes, 26. language for text processing , 27. the product for the sorting and connection of data sets in the SCOPE 3.3.X system, 28. language for the writing of compilers and systems programs

--changes in the standard software for the perforated tape station.

Training in the exploitation of program libraries and the considerable development of the plotter's standard software also had tremendous importance for raising the system's effectiveness.

Several programs which streamline the system's exploitation were worked out in the Division for the Coordination and Organization of Production. CYFRONET-Cracow rejected the purchase of a developed (and costly) accounting system which uses BAROMETER and has prepared its own system which is composed of several programs written in COBOL. Accounting is performed on the local scale and presently subject to it are: the number of completed tasks, the systems time, the size of input and output sets, the number of magnetic tapes used, the number of cards read in, the number of lines printed, and for interactive operations, the systems time and that of terminal addition.

Modifications of programs registering the system's equipment failure and the development of their own program which registers magnetic tape use and the appearance of tape errors and rewind are all essential for exploitation. Also perfected is the present printout of permanent sets, dividing them according to institution (user) and introducing the possibility of printing the appropriate statement fragments on the printers of the individual terminals. Presently, the magnetic tape preparation program is being streamlined with a record for the plotter and the program, optimizing plotting on a sheet of the plotter's paper, is being put into use.

THE SYSTEM'S USES

In accordance with the given configuration, the digital system includes a

series of terminals. They are installed in the following universities and institutes: Jagiellon University, the Institute of Mining and Metallurgy, the Cracow Polytechnic, the Academy of Economics, the Academy of Agriculture, the Academy of Medicine, the Pedagogical High School, the Institute for Nuclear Physcis and the Institute for Rock Mass Mechanics of the Polish Academy of Sciences.

The considerable computation power (the fast central processor, the large operating and internal memories), the developed operating system, the numerous programming languages, the comprehensive orogram library--all cause the SCO computer system to accomplish its quite varied functions.

Some 800 scientific workers from various disciplines and numerous groups of students from Cracow's universities preserly collaborate with CYFRONET. The SCO's operation also includes other academic regions, performing computations for the University of Wroclaw, the Silesian Polytechnic, the Rzeszowski Polytechnic and the Pedagogical High School in Czestochowa. Many scientists from all disciplines--mathematicians, physicists, doctors, sociologists, agriculturists, chemists, engineers, astronomers, biologists, linguists, economists, informaiton specialists, archeologists, meteorologists, geographers--make up this rather large group of users. Computers concern the didactic process itself and are tied to scientific operations. Moreover, they hasten the return of research data. Most importantly, however, is that in the complex configuration of the interaction of the great universities, scientific institutes and CYFRONET, computation has been and is being performed, which has great importance for the national economy and international cooperation. One can mention here as examples such current governmental problems as:

--optimizing the production and consumption of protein,

--combating newly caused diseases,

--the development of housing,

---coal processing,

--the transformation and utilization of water resources,

--the development of materials and subsystems for the needs of electronization.

EXPLOITATION

The rapid growth of the system's load was quite characteristic. In the first half of 1977, several thousand tasks were performed monthly, taking up around 3 million systems seconds. The two charts show data on the system's exploitation from September 1975 until June 1977.

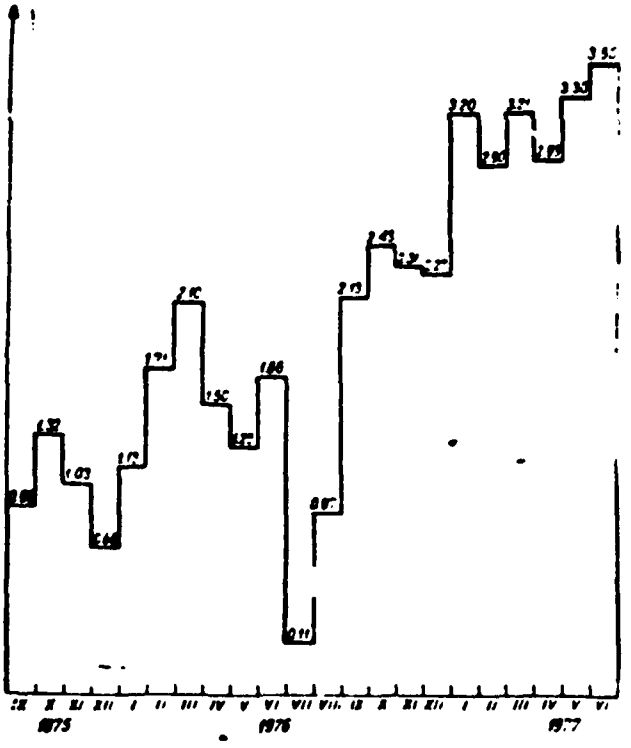

Chart 1. The CYBER 72 computer's load from Sept 1, 1975 until June 30, 1977 (in million systems seconds).

Such considerable use of the system was possible not only thanks to the high qualificaitons of CYFRONET's staff, but also to the existing harmony, which facilitated cooperation with the scientific community. The close ties with the universities and institutions assumed various forms. The Scientific Board, created by the Ministry of Science, Higher Education and Technology, is working with the SCO CYFRONET-Cracow. The board includes independent scientific workers from the institutions--system subscribers and information specialists from universities in the Cracow region. Also, two commissions have been created within the Scientific Board: one for statistics and the other for the automatization of experiments. CYFRONET maintains direct contacts with the universities through representatives of the rectors (of of the institutes' directors), information specialists and the terminal directors who, collaborating with the Division for the Coordinaiton and Organization of Produciton, actively participate in solving the problems of exploitation.

The role played by individual scientific institutions in the system's use is quite varied (chart 2) and therefore cannot constitute the basis for establishing priorities. The efforts of the region and CYFRONET is aimed at allowing the university or institute centers some computer use. It is, however, a difficult task and in the end is also not very efficient. The only solution is to obtain more equipment, which would, in the surest way, guarentee access to the system in accordance with the present neeeds of science.

PAYMENT PRINCIPLES

In accordance with the law, scientific computation for higher educational institutions subordinated to the Ministry of Science, Higher Education and Technology is performed free of charge. Initially, some subscribers used the

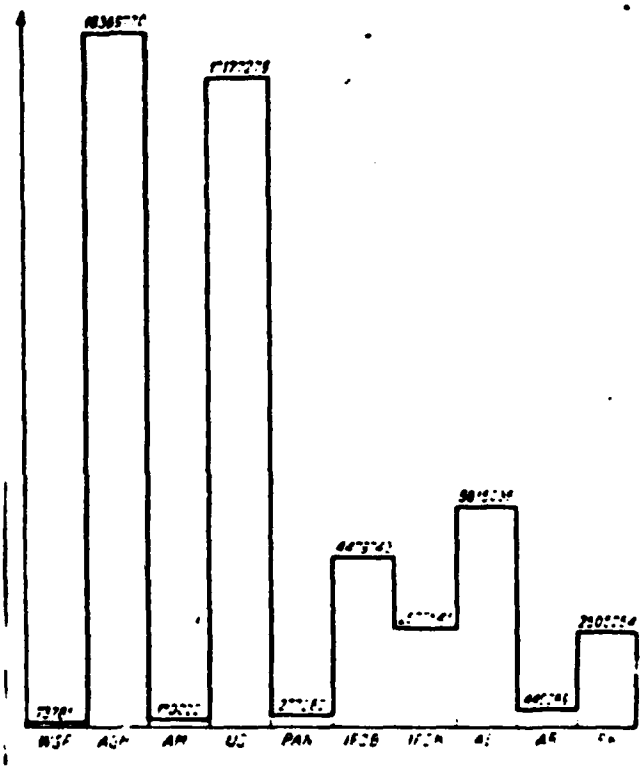

Chart 2. The CYBER 72 computer usage time from Jan. 1 1975 until June 30, 1977 by individual user (in systems seconds)

computers uneconomically and hence in 1976 the Commission for Program Verification was formed. Experts, holding the trust of the representatives of the various educational institutions, entered into the commission's composition. They reviewed many of the programs. They turned their attention not only to the economical planning of printouts and the appropriate use of permanent sets, but also sought the optimization of programs, the appropriate choice of problem

solving methods and corresponding numeric methods. The commission's one and a half year activity had an expressed effect and confirmed the validity of its inception.

In discussion the Center's operation it is difficult to ingnore its very diverse activities, which aim at the procurement of the highest level possible of informational knowledge in Cracow's universities and scientific institutions. Of the greatest importance here are the permanent courses offered by CYFRONET's personnel which are becoming more and more popular in Cracow's scientific circles. The individual contacts of users with experts from the programming departments are also very important. Publishing activity also serves to raise the level of informational knowledge in the Cracow region. CYFRONET has published pamphlets, which discuss the basic problems connected with the CYBER system's use, copies of FORTRAN handbooks and a discription of the CERN library. It is also preparing a subsequent pamphlet on the subject of the CYBER system and thematic descriptions of program libraries originating from various libraries (for ex. programs which concern the solution of various equations or programs dealing with statistical analysis).

The two year operation of the Regional Computation Center CYFRONET-Cracow has shown a real advantage for scientific insitutions. By this fact alone, it is possible to speak of the full accomplishment of complex tasks.

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